HOUSING DEPRECIATION AND OPTIMAL TAX POLICY**

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ABSTRACT

In spite of the importance and controversy of real property depreciation allowances, little empirical work has been done on the subject. This paper is based on an empirical analysis of housing structure value and age. Depreciation estimates of single family houses and apartment buildings are derived from regression analysis. The time rate of depreciation for residential buildings, as derived from this research, is approximately 0.7 percent per annum, much lower than that allowed by current IRS policy.

TAX deductibility of depreciation for rental property is a salient and often controversial feature of United States income tax policy. Real estate is treated on par with all other productive assets that are ultimately exhausted after some finite service life. Equitable treatment among all taxpayers does require that allowances be made for capital consumption without discrimination against particular asset classes. However, in the case of real property critics interested in tax reform have stated that existing Internal Revenue Service policy is far too lenient; it allows guideline service lives for buildings that are too long and depreciation rates which are too high, although the opposite is often claimed by investors.[1] If this is true, it follows that the tax structure favors real estate owners at the expense of all other taxpayers and leads to distortion in resource allocation. Also, some externalities such as landlord disinvestment leading to slum creation have been blamed on investor response to income tax considerations.[2]

In spite of the important fiscal and equity issues concerning housing depreciation policy, it is surprising how little actual empirical work has been done on the subject.[3] It is the purpose of this paper to first determine an empirically based rate of housing depreciation and then compare this true rate with that allowed by current IRS policy. There are three parts to this paper: (1) development of a theoretical model of housing depreciation which is consistent with cross-sectional empirical research, (2) estimating the true rate of depreciation as interperiod changes in value, and (3) analyzing the efficacy of federal tax policy by comparing the empirically determined depreciation rate with that allowed by IRS.

1. Depreciation and Market Value

The capitalized value of a particular residential property is a function of the value of future housing services it offers. The result is a market price which is the discounted present value of the expected flow of these varied services after taxes. Let H be a vector of various housing services such as shelter, security, accessibility, amenity and others, and let Z be the residual value, positive or negative, when the building is demolished, T the terminal date, m the investor's marginal tax bracket, and a is a capital gain tax modifier reflecting preferential capital gain treatment.[4] Then the market value of a unit of vintage k in year t_0 is

$$V(k,t_0) = (1 - m)\left\{\sum_{t=t_0}^{T} \frac{H_{t_0}}{(1 + r)^{t-t_0}} + \frac{Z(a)}{(1 + r)^{T-t_0}}\right\}. \quad (1)$$

Should the quality of this service stream or the length of the remaining service life be altered, the market value will change. Abstracting for the moment from changes in the price of housing services in general, changes in value of a housing unit result from changes (or expected changes) in the generation of housing services of the unit through time. It should be noted that the level of services is dependent upon the

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expenses incurred by the owner for maintenance and operation, which therefore affect value changes through time. The property owner has incentives to optimize maintenance and operating expenses, resulting in some optimum time path of value of the asset. Whatever the expenses incurred, there will be a resulting time path of asset value.

The value of housing services offered by any housing unit may be disaggregated with price and quality components such that

$$H = PS \tag{2}$$

where S is a measure of housing services in physical terms and P is the price per unit of the services. Houses at any point in time differ in value because of differences in the level of services they offer. The price of housing services, P, may change through time affecting the value of all houses due to inflation, changes in the costs of providing housing relative to other goods and demand changes affecting values placed on housing services.

Substituting (1) into (2), the market value of a housing unit of vintage k in year t_0 can be expressed as

$$V(k,t_0) = (1 - m)\left\{\frac{P_0S_1}{1+r} + \frac{P_0S_2}{(1+r)^2} + \ldots + \frac{P_0S_{T-t_0}}{(1+r)^{T-t_0}} + \frac{Z(a)_0}{(1+r)^{T-t_0}}\right\} \tag{3}$$

where P_0 is the price of housing services in time period t.

Assume now that the price of housing services changes from P_0 to P_1 in period $t_0 + 1$. Then the value of the same housing unit in period $t_0 + 1$ will be

$$V(k,t_0+1) = (1 - m)\left\{\frac{P_1S_2}{1+r} + \frac{P_1S_3}{(1+r)^2} \ldots \frac{P_1S_{T-t_0-1}}{(1+r)^{T-t_0-1}} + \frac{Z(a)_1}{(1+r)^{T-t_0-1}}\right\} \tag{4}$$

The change in value between periods t_0 and $t_0 + 1$ is found by subtracting (4) from (3).

$$\Delta V(k) = (1 - m)\left\{\frac{P_0S_1}{1+r} - \frac{S_2}{(1+r)^2}[-rP_0 + (P_1 - P_0)(1+r)] - \frac{S_3}{(1+r)^3}[-rP_0 + (P_1 - P_0)(1+r)] \ldots - \frac{S_{T-t_0}}{(1+r)^{T-t_0}}[-rP_0 + (P_1 - P_0)(1+r)] + \frac{Z(a)_0}{(1+r)^{T-t_0}} - \frac{Z(a)_1}{(1+r)^{(T-t_0-1)}}\right\} \tag{5}$$

The specific form of (5) is obtained by adding and subtracting the quantity $P_0(1 + r)$ in each bracketed term on the right hand side.

When written in this form, the right hand side of (5) can be broken down into two separate sums. The first sum collects all the $(P_1 - P_0)$ terms. Thus the change in value given by (5) is

$$P_0\left[\frac{S_1}{1+r} + \frac{rS_2}{(1+r)^2} + \frac{rS_3}{(1+r)^3} \ldots + \frac{rS_{T-t_0}}{(1+r)^{T-t_0}}\right] + \frac{Z(a)_0}{(1+r)^{T-t_0}} - \frac{Z(a)_1}{(1+r)^{T-t_0-1}} \tag{6}$$

plus the term

$$(P_1 - P_0)\sum_{t=t_0+1}^{T}\frac{S_{t-t_0}}{(1+r)^{t-t_0}} + \frac{Z(a)_0 - Z(a)_1}{(1+r)^{T-t_0-1}}. \tag{7}$$

Expression (6), the first of the two sums, is the effect of the passing of time on future housing services in physical terms that will be obtained from the building. Two major considerations determine this sum. First since the building has a finite life, the passing of each period brings the terminal date closer. This generally reduces the total present value since the number of service periods is diminished. The second consideration is the fact that the level of housing services provided by the structure tends to decline with age as buildings wear out and become obsolete, i.e., usually $S_1 > S_2 > S_3 > \ldots > S_n$.

The second component of value change, given by (7), is the result of housing service price changes, i.e., changes in the value of a given amount of service. In a period of rising prices this quantity will be in the opposite direction from the market value of the change in physical services given by (6). If the rise in the price level is large enough the result may be negative change in value, or appreciation. That is, the value at the end of the period may exceed the value at the beginning.

Accountants and others have, for better or worse, decided that they wish to define depreciation as change in value through time in the absence of changes in the general value of housing services. That is, the accounting concept of depreciation is given by (6). Given this as a definition of depreciation, the question becomes how to measure it. To consider this question, (3) can be used to obtain an expression for the value of different vintages at any one point in time.

Again consider the housing unit of vintage k at time t_0. At this point in time the price of housing services is P_0. The value of the housing unit is

$$V(k,T_0) = (1-m)\left\{\frac{P_0S_1}{1+r} + \frac{P_0S_2}{(1+r)^2} \ldots + \frac{P_0S_{T-t_0}}{(1+r)^{T-t_0}} + \frac{Z(a)_0}{(1+r)^{T-t_0}}\right\}. \quad (8)$$

Now consider a housing unit of an earlier vintage $(k-1)$ at time t_0. The price per unit of housing service is still P_0, but the housing unit of vintage $(k-1)$ is now in its second period of operation. Its market value is

$$V(k-1,t_0) = (1-m)\left\{\frac{P_0S_2}{1+r} + \frac{P_0S_3}{(1+r)^2} \ldots + \frac{P_0S_{T-t_0}}{(1+r)^{T-t_0-1}} + \frac{Z(a)_0}{(1+r)^{T-t_0-1}}\right\} \quad (9)$$

The difference in market value between the two housing units obtained by subtracting (9) from (8) is

$$V(k,k-1) = (1-m)\left\{\frac{P_0S_1}{1+r} - \frac{(S_2P_0)r}{(1+r)^2} - \frac{(S_3P_0)r}{(1+r)^3} \ldots - \frac{(S_{T-t_0}P_0)r}{(1+r)^{T-t_0-1}} + \frac{Z(a)_0}{(1+r)^{T-t_0}} - \frac{Z(a)_1}{(1+r)^{T-t_0-1}}\right\} \quad (10)$$

It can be seen that this is identical to that quantity calculated as the difference between (4) and (3) which is the accounting definition of depreciation. That is, the cross section comparison will provide a measure of the first component of value change but not the second, since it omits the price level component. Therefore the cross section comparison at a point in time will give estimates of depreciation consistent with accounting convention.

II. Measurement of Depreciation

Equation (6), the definition of depreciation, does not lend itself readily to estimation. For the purposes of empirical work, it is assumed that the market value of a housing unit aged t, V(t), is the product of its replacement cost, R, site value, S, and the depreciation factor, D(t):

$$V(t) = R + S - D(t). \quad (11)$$

This particular valuation method, equation (11), is known to real estate appraisers as the cost approach. Its theoretical foundation is the principle of substitution. That is, a rational consumer would pay no more for a house (or any other asset) than the cost of a substitute which provided equal utility. Although the use of estimated quantities for replacement cost and site value may introduce some measurement errors there is no *a priori* reason to believe that the methodology in question produces errors which are not randomly distributed.

The estimated value of the structure V_b, may be obtained by subtracting appraised site value from total selling price

$$V_b = V(t) - S = R - D(t) \tag{12}$$

If the appraised site value is an unbiased estimate of the true site value, then structure value V_b is unbiased though again subject to possible measurement error.

Equation (12) readily lends itself to estimation procedures. If D(t) is of the form $e^{-\delta t}$ (12) can be transformed into

TABLE 1

VALUE OF STRUCTURE LOG-LINEAR REGRESSIONS[a]

Variables	SINGLE FAMILY HOUSES 1a	1b	APARTMENT BUILDINGS 1c	1d
Constant	.539	.405	2.153	1.589
Replacement Cost	.931 (.024)	.944 (.025)	.824 (.083)	.861 (.034)
Condition	.119 (.021)	.116 (.022)	-.001 (.045)	.024 (.045)
Age	-.0070 (.0005)		-.0072 (.001)	
Age Dummy Variables				
1. 10-19		-.066 (.030)		.135 (.058)
2. 20-29		-.089 (.035)		-- --
3. 30-39		-.177 (.034)		-.232 (.105)
4. 40-49		-.285 (.037)		-.194 (.060)
5. 50 and over		-.393 (.037)		-.309 (.071)
R^2	.789	.794	.806	.818
Standard Error	.204	.203	.283	.277
Degrees of Freedom	472	468	162	159

[a] All variables are expressed as natural logarithms except age and the dummy variables.

$$\log V_t = \log R - \delta t. \quad (13)$$

Alternatively D(t) can be approximated in a regression by a series of dummy variables for various time periods.

Empirical Estimation of Structure Depreciation

Data used in the empirical analysis were obtained from three savings and loan associations in the San Francisco Bay Area. Each observation is based on a market transaction which occurred between 1969 and 1971. At the time of each transaction the lending institution performed a value appraisal of the property using both market comparisons and the replacement cost methods. For each transaction the lending institution provided the actual sale price, estimated replacement cost and site value, the appraiser's judgment of structure condition, and the estimated age of the building.[5]

Regressions of estimated structure value on replacement cost, condition, age, and age dummy variables are shown in Table 1. In log-linear form the rate of depreciation is the coefficient of the age variable, i.e., the rate of change in structure value with age, which is assumed to be an exponential decay function. In equations (1a) and (1c) the estimated rates of depreciation are .70 percent per annum

TIME PATH OF DEPRECIATION

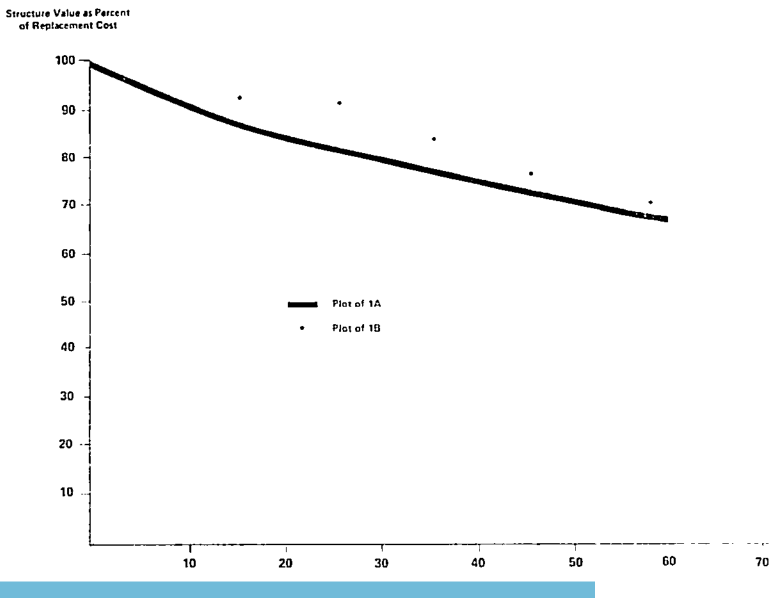

FIGURE 1
SINGLE FAMILY HOUSES PERCENT

for single family houses and .72 percent per annum for apartment buildings. The results for the two different kinds of structures are remarkably similar. Conventional wisdom suggests that the rate of depreciation for apartment buildings should be higher than that for single family houses under the assumption that landlords and tenants do not exercise the same degree of maintenance as homeowners. However, this opinion is not substantiated by this finding.

In equations (1b) and (1d) a series of dummy variables is used for ten year age cohorts rather than numerical age. These age dummy variables tend to show the same general pattern of depreciation with increasing absolute magnitudes of the coefficients with age.[6] These age dummy variables also provide a rough test of the adequacy of the exponential decay depreciation model of (1a) and (1c). A plot of the depreciation patterns for the single family houses indicated by (1a) and (1b) is given in Figure 1. The points indicate the percent depreciation taken from the dummy variables and the line the path indicated by the exponential depreciation function. The points were plotted for the midpoint of the range for each dummy. The two plotted functions appear to trace out similar paths. But the dummy variables indicate a depreciation pattern characterized by a relatively lower initial rate than indicated by the exponential function. However, care must be taken in interpreting this graph. There are other differences in the equations, reflected in different coefficients for the constant term and for replacement cost.

Though there has not been much empirical work on housing depreciation these results are not inconsistent with studies of commercial building depreciation. Taubman and Rasche calculated the true rate of depreciation of office buildings at between .0025 and .0050 per annum. Hulten and Wykoff examined a variety of industrial and commercial buildings and reported depreciation rates in the neighborhood of one to two percent per annum. Hotels and apartment buildings had the lowest rates and industrial buildings the highest, as might be expected.

III. Implications for Federal Tax Policy

Depreciation for tax purposes is calculated on the basis of original acquisition cost using guideline lives established by the Internal Revenue Service. The guideline life is 40 years for new residential structures. Using the straight line convention and 40 year life, the allowable depreciation for tax purposes is .025 of the acquisition cost per annum, and the double declining balance method is twice that for the first year. However, this study indicates that the appropriate rate of depreciation for housing is .007 of the underpreciated replacement cost per annum. Although these two rates are not on comparable bases, their effects can be compared as in Table 2, using a hypothetical structure with an initial cost of $10,000.

The consumption of real capital, as determined by changes in market value, is designated real depreciation, and calculated as .007 of the replacement value on a declining balance basis. The depreciation allowed by the IRS for tax purposes is designated as the nominal depreciation and calculated as .025 of the original cost using the straight line conventions, and under some conditions .050 on the double declining balance method. Direct comparisons may be made of columns 1, 4 and 9 which show the difference in the amount of depreciation produced in the various years and over the 40 year period using all three conventions. Nominal depreciation for tax purposes is much greater than the real rate of capital consumption as shown in columns 1, 4 and 9.

Since the asset depreciates over a long period of time the three depreciation streams should be discounted to obtain their present values. The rate used is the real interest rate, which in this case is assumed alternatively to be three and ten percent.[7] Even after discounting the present value of the nominal stream of depreciation for tax purposes is approximately three to four times larger than the real depreciation which is based on actual capital consumption.

TABLE 2

REAL AND NOMINAL DEPRECIATION ON STRUCTURE WITH HYPOTHETICAL COST OF $10,000

	Real Depreciation Discounted at:			Straight Line Nominal Depreciation Discounted at:									
	0% (1)	3% (2)	10% (3)	0% (4)	3% (5)	10% (6)	13.2% (7)	38.5% (8)	0% (9)	3% (10)	10% (11)	20.8% (12)	60.2% (13)
Year 1	$70	69	64	250	243	227	220	181	500	485	454	414	312
Year 10	66	49	27	250	186	96	72	10	315	234	121	48	3
Year 20	61	34	10	250	138	37	21	-	189	109	28	7	-
Year 30	57	23	4	250	103	14	6	-	113	46	-	-	-
Year 40	53	16	2	250	77	6	1	-	64	20	-	-	-
Total of All Years[a]	$10,000	1,870	650	10,000	5,778	2,439	1,870	650	10,000	6,024	3,331	1,870	650

[a]Columns (1), (2) and (3) discounted over an infinite horizon; columns (4)-(13) discounted over a 40 year horizon.

Defenders of IRS policy point to the fact that depreciation for tax purposes based on historical cost may be eroded by inflation since the real value of the nominal depreciation charges is diminished. Therefore the disparity between real and nominal depreciation in a period of inflation is not as great as that shown between columns 2, 5 and 10 or columns 3, 6 and 11 which assume no price level change. The rate of inflation which will make the real and nominal depreciation streams equal can be found by finding the nominal discount rate which will make the nominal depreciation flow equal to the real depreciation flow discounted at the real rate of interest.[8] Column 7 shows that the present value of nominal depreciation for tax purposes discounted alternatively at rates of 13.2 and 20.8 percent is equal to the real depreciation discounted at a 3 percent real rate of interest (column 2). For a 10 percent real interest rate the appropriate nominal rates are alternatively 38.5 and 60.2 percent shown in columns 8 and 13. Therefore, it would seem that nominal depreciation for tax purposes exceeds the real rate of capital consumption for all rates of inflation up to 10 percent per annum, for a real rate of interest of 3 percent and up to 28 percent per annum for a real rate of interest of 10 percent.

Historically, the rate of inflation has not been so high as to justify IRS allowable depreciation. From 1950 to 1970 the Consumer Price Index and Composite Construction Price index maintained by the Department of Commerce grew at rates of 2.5 and 3.5 percent per annum respectively. The most recent figures show that from 1970 to the beginning of 1977 the annual rates of growth were 6.5 percent for the CPI and 8.2 percent for the Department of Commerce Construction Price Index. In order for the currently allowable depreciation for tax purposes to equal the real rate of capital consumption a period of sustained inflation at a rate much higher than has been true historically would be required. These results were based on using the straight line method which is the most conservative depreciation convention. Had accelerated depreciation been used the calculated subsidy would have been greater.

FOOTNOTES

**I wish to thank Sidney Davidson, George Tolley, Charles Upton, Brian Berry, Nicolas Dopuch and Pete Pashigian of the University of Chicago for their assistance in this research.

[1]Criticisms of real property depreciation practices are made by Surrey, Aaron, and Taubman and Rasche.

[2]The accusation that excessive depreciation allowances lead to slum creation is found in Sporn.

[3]Works of interest on the subject of building depreciation are by Rydell, Grigsby, Handler, Taubman and Rasche, and Hulter and Wykoff.

[4]This formulation is consistent with the revisions of the tax code in 1976 which retains the tax preference for capital gains and the limited recapture of depreciation, or the excess of accelerated depreciation over depreciation computed using the straight line method. The Tax Reform Act of 1976 retains the provisions for accelerated depreciation for housing. The law eliminates the immediate write-off of construction interest. It tightened the recapture requirements by eliminating the partial forgiveness for the length of the holding period for all real estate other than low income rental housing. For low income housing there is no recapture of excess depreciation after 16-2/3 years. Although some significant changes were made in the tax law with the 1976 Tax Reform Act they do not affect the valuation model shown as equation (1).

[5]The condition of each building was judged by the appraiser on an ordinal scale of (1) excellent, (2) good, (3) average, (4) fair, or (5) poor. However, no buildings in the sample were judged to be in fair or poor condition. Apparently such properties are either brought up to at least average condition at the time of sale or are financed through media other than savings and loan associations. A dummy variable for condition was created which registered 1 for either excellent or good condition and 0 for average condition. Thus the dummy variable in Table 1 indicates the value added by above average condition.

[6]The positive sign of the first age dummy variable in (1d) is inexplicable. A literal interpretation is that those apartment buildings in the sample tended to experience appreciation in the early years. As a further note, there were too few observations of apartment buildings in the age cohort (20–29) years. This period does coincide with a period in which very few apartment houses were built in the United States.

[7]Alternative estimates of the real rate of interest were selected for this computation in order to specifically avoid the controversy over the magnitude of the real interest rate. The point being made with this computation is not sensitive to a particular rate of interest.

[8]The rate of discount, or nominal interest rate, is the real interest rate plus the expected rate of inflation.

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